MASTER PROJECT INTEGRAL DESIGN: START UP FOR STUDENTS BASED ON WORKSHOPS FOR PROFESSIONALS A COMPARISON

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Following the developments in (Dutch) building practice, where besides specialist skills an multidisciplinary design approach is increasingly being asked, the Building Services chair of the Faculty of Architecture, Building and Planning of Technische Universiteit Eindhoven (TU/e) initiated in the academic year 2005/06 a multidisciplinary masters project 'Integral Design'. The basis for this project was a developed Integral Design method which uses a morphological overview as a tool, tested in a workshop setting with experienced practitioners from the Royal Institute of Dutch Architects (BNA) and the Dutch Association of Consulting Engineers (NL Engineers). The results of students and professionals are compared.

Keywords: Integral Design, workshops, master students, professionals.

1. INTRODUCTION

Currently the built environment uses 40% of all our energy, this has to change. Limitations of our supplies of fossil fuel, and environmental problems related to the use of fossil fuel urge the need for a more sustainable built environment. Growing awareness of global warming led to planned actions to reduce carbon dioxide emissions. As the built environment is responsible for nearly 40% of CO_2 emissions new approaches are necessary. This led to the development of Zero Emission Building. A Zero Emission Building means a building which emits virtually '0 (zero)' carbon dioxide [1]. However this new target in building design, ZEB requires totally different approach from conventional building in terms of design, construction and operation [1, 2]. That goal is very ambitious for the moment [3] and can only be realized by applying renewable energy source and an extreme low energy use of the building. Such a complex design task requires early collaboration of all design disciplines involved in the conceptual building design.

Architects and engineers need to be able to handle the challenges imposed by the new design goals. Models are needed to bridge the gap between the worlds of Design Methodology and Reflective Practice, and to look at designing as a process in which the concepts of function, behaviour and shape of artefacts play a central role [4]. This integrated approach shows high promises to reduce failure costs and improve design quality can eventually lead to integral process, team and method — all the required conditions for design of the end product; the building [5]. Design education needs to help engineering students and architectural students to develop the necessary skills to successfully handle design tasks [6]. Development of knowledge and skills by students and so give them the ability to realise this aim is the main intention of the multidisciplinary masters' project 'Integral design'.

To test our ideas for a new educational approach experiments were done in a situation as close to design practice as possible: in workshops for professionals. The professional workshop formula was used to start the students' master project integral design team work. This makes it possible to compare the design approaches of the students with that of the professionals [7], but that is not the focus of this paper. Education should prepare students to become professionals therefore it is of importance to look into the appreciation of the proposed design tool within building design practice. The focus of the

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article is on the value of the method and tools used in the workshops for professionals and compare that with the evaluation of the design method and tools by our students.

The methodology, the used design method and its tool, morphological overview, are described in Section 2. Section 3, describes the workshops for professional architects and engineers. Our Master project Integral design uses the same concept as a start-up for the project. Using the professional workshops' setup brings experience from practice to the university. In Section 4 the results are given of the different questionnaires that were held to gain insight in the appreciation of different aspects of the design tool used in the workshops. Especially a comparison is made between the results of professionals and those of the students. After a short discussion in Section 5 conclusions are given about whether or not both students and professionals think the integral design method is useful for them.

2. METHODOLOGY

As complexity and scale of design processes in architecture and in building services engineering increase, as well as the demands on these processes with respect to costs, throughput time and quality, traditional approaches to organize and plan these processes may no longer suffice [8]. This implies defining a process methodology that acts as a "bridge" between architectural elements such as shapes and material on the one hand, and the aspects of indoor climate issues such as overheating and ventilation on the other.

Integral Design [9] was chosen as a starting point of development based on methodical design a well known design method in the Netherlands [10], it is a design process model; the cycle (define/analyze, generate/synthesize, evaluate/select, implement/shape) forms an integral part in the sequence of design activities that take place [11]. A distinguishing feature of Integral Design is the intensive use of morphological charts for design steps in the design process. The use of morphological chart is an excellent way to record information about the solutions for the relevant functions and aid in the cognitive process of generating the system-level design solution [12]. Morphological charts to visualize solution alternatives play a central role in the integral design approach for design teams. Each participant of a design team develops a full morphological chart from their own specialist point of view. These individual discipline based morphological charts can be combined to one overall morphological chart, called morphological overview. The morphological overview of an integral design team process is generated, by combining in two steps the different morphological charts made by each discipline. Putting the morphological charts together enables to 'put on the table' the individual perspectives from each discipline about the interpretation of the design brief and its implications for each discipline. This enable, support and stimulates the discussion on and the selection of functions and aspects of importance for the specific design. In step one the functions and aspects are discussed and decides with are placed by the team in the morphological overview. After this in step 2 all participants of the design team can come up with their solutions for these functions and aspects, see Figure 1.

Although the use of morphological charts based on functional decomposition is quite common in mechanical engineering design, they are rarely used in a multi-disciplinary way besides the mechanical engineering domain. Comparing the use of morphological charts by engineers and architects we found out that architects use the morphological charts more like a tool for brain writing. The functions and aspects are developed in a kind of mind mapping and put into the morphological chart. Almost all architects make no clear distinction between aspects/functions and possible sub solutions. Engineers and especially structural engineers work more in the traditional way of functional decomposition. The input of 'soft' architectural aspects adds a new dimension to the traditional strict functional approach of morphological charts, see as an example the aspect 'child-friendly, healthy' in the morphological overview in Figure 2 [13, 14]. It is important to divide the process leading to the morphological overview into two steps to structure the discussion between the different disciplines about the most important functions and aspect in relation to the design brief. In this discussion the interpretation by each discipline of the design brief becomes transparent and different insights can be discussed. After the important first step the solutions by all the different disciplines can be added. The result is a

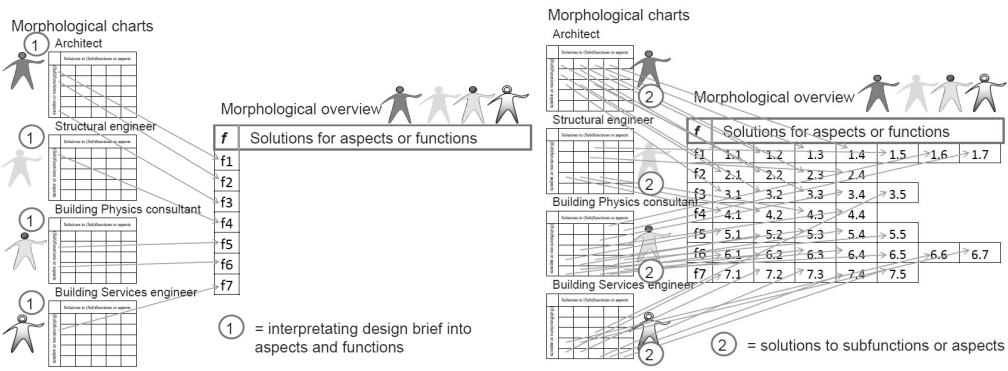

Figure 1. Two steps to come from the morphological charts to the morphological overview.

Design aspects/ functions:	Sub solutions:					
(1) Sustainability {Team}	(1-1) 'green' façade {A}	(1-2) PV/T shadings {BS}	(1-3) 'buffering' for humidity {A}	(1-4) roof garden {BS/A}		
(2) child-friendly, healthy {Team}	(2-1) Scale, identity {A}	(2-2) natural materials {BS/A}	(2-3) structure, protection {A}	(2-4) open façade, windows {A}		
(3) Natural ventilation {Team}	(3-1)HOLCOM For ventilation {BS}	(3-2) higher classrooms {BS}	(3-3) walls for ventilation {BS}	(3-4) building orientation {BS}		
(4) Energy sustainability {Team}	(4-1) photo-voltaic thermal	(4-2) adiabatic cooling {Brief}	(4-3) air-inlet via underground {BS}	(4-4) CHP for winter {BS}	(4-5) floor heating {A/BS}	(4-6) sprinkler comb. cooling {A}
(5) Flexibility {Team}	(5-1) Columns {SE}	(5-2) Walls {SE}	(5-3) C/W Combination {Team}	(5-4) System plafond {A}	(5-5) 'Clear' plafond {A}	(5-6)HOLCOM floor {A}

Figure 2. Transcript in English of the design team one's original morphological overview in workshop series 5 with the source of the information; A-Architect, BS-Building Services engineer, SE-Structural Engineer, Brief is the design brief.

transparent and clear overview of the interpretation of the design brief by the design team as well as an overview of the known possible sub solution by the members of the design team.

3. EXPERIMENTS: WORKSHOPS

One of the difficult aspects of conducting design research is finding suitable participants for experimental testing. Mostly verification and testing of a new method or tool is done by experiments with student groups [15] or with design groups within one company [10]. By using experienced designers we wanted to improve the relevance, as there is a major difference between the design approach of experts and novice designers [16–18]. In the project different possibilities were evaluated [19] and the form of workshops was chosen to evaluate the outcome of the integral design method to support the building design process.

3.1. Development of the professional workshops

Since 2005 we organized 5 series of workshops with experienced professionals, architects and engineers, voluntarily applying to participate [13]. The integral design method with its use of morphological charts and morphological overviews was tested in the still ongoing series of workshops organized in cooperation with BNA (Dutch Royal Society of Architects) and NL Ingenieurs (Dutch

Association of Consulting Engineers). All professional participants are experienced practitioners who voluntarily apply for "learning-by-doing 'Integral design' workshop course". The only selection criterion used is the requirement to be a member of either BNA or NL Ingenieurs. The participants are randomly assigned to design teams, which ideally would consist out of one architect, one building physics consultant, one building services consultant and one structural engineer.

Starting with a three-day set up, the integral design method workshops have evolved to finally a two-day set up. More information about the first three series of workshops can be found in [9, 19]. The experiences of workshops series led to step by step adjustments resulting in the final setup workshop which was used in series 4 and 5, see Figure 3.

During two days there are four different design sessions during which the team has to perform a specific design task. The design tasks during these two days are on the same level of complexity and have been used in all workshops. After each design session the participants present the results to each other and get feedback from the organizers. The participants are rearranged after each design session so that no one works together with someone else more than once, this to avoid a learning effect in the teams during the different design session.

The workshops start with a lecture introducing Integral Design and are followed with other supportive lectures about sustainable energy systems, the use of morphological overviews and overall feedback of the results to all participants. The workshops typically include around twenty participants.

In this final configuration of the workshop series (Figure 3) stepwise changes to the traditional building design process, in which the architects starts the process and the other designer join in later in the process, are introduced in the design sessions. Starting with the traditional sequential approach during the first design session on day 1, this provides the participants a kind of reference experience so in session 2 they can get the understanding how the process changes by letting all disciplines start working simultaneously from the very beginning of the conceptual design phase.

After the first day the application of the integral design model/morphological overview is introduced in session 3. During the second day of the design workshops the sessions allows simultaneous

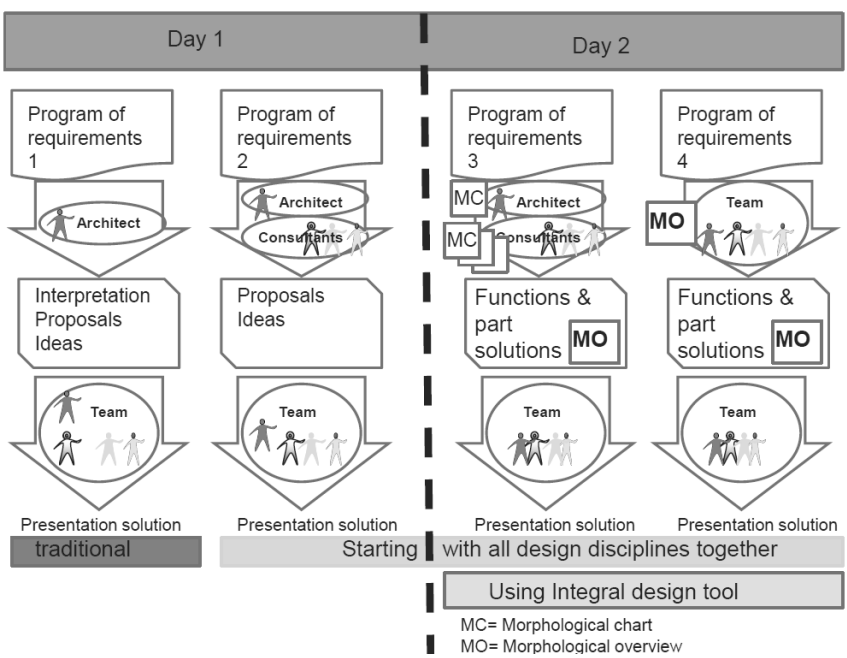

Figure 3. Setting of workshops series 4 & 5, four design sessions with different set ups of participants and use of Morphological Charts (MC) or Morphologic Overviews (MO) in two days.

involvement of all design disciplines on a design task, aiming to influence the amount of considered design functions/aspects by giving the teams tools of Integral Design; morphological chart and morphological overview. The application of morphological overviews during the third design session demonstrates to the participants the effect of transparent structuring of design functions/aspects on the amount of generated (sub) solution proposals. At the end of the third session the participants receive feedback about their applying the morphological charts and morphological overview. So the third session provides the possibility of one full learning cycle regarding the use of morphological overviews. After this third learning session the participants can apply the morphological in the intended way and is it possible to investigate the effect of the use of the morphological overview. So in design session 4 the design teams really can experience the effect of the integral design method and its tools, morphological charts and morphological overview.

3.2. Multidisciplinary master design project for sustainable climatic design

Interaction between practice, research and education forms the core of our integral design approach. Therefore we implemented the integral design workshop for professional's set up within the start-up workshop of our multidisciplinary master project integral design. Students from architecture, building physics, building services, building technology and structural engineering were offered the opportunity to participate. Because of the intensive coaching not more than six teams were formed. The procedure for the start-up workshop for the student's project was the same as for the professional workshops; the only criterion for participation was the 'membership' of the 'master students group'. The students of each discipline were randomly assigned to design teams, with the aim to have all disciplines represented in each team. This makes it possible to compare the student workshops with the results from the workshops for professionals. In this article the focus is on the effect of the workshops at the start of the project and is the rest of the project not discussed. The focus of our research is on developing a design method and design tools based on extensive testing in a professional setting. Through questionnaires for professionals, as well as for students, different aspects are compared related to the use of the tool in the workshops.

4. RESULTS

The results of the workshops in their final form held for professionals and students are compared. In the compared final two workshops series 38 professionals participated, average age 42 and on average 12 years of design practice experience. In the two parallel workshops for students 42 participated, average age 23 and no design experience from practice. Direct at the end of the workshops the participants were asked to fill in a questionnaire about the use of morphological overviews during the design sessions and about the concept of the workshops themselves. The results of the comparison are given in Table 1 and Figures 4 and 5.

Table 1. Questions and result answers of the questionnaires on a scale from (1–10).

	Professionals	Students	• in %
Number of participants	38	42	
Response [%]	95	76	
MO increases the number of relevant alternatives	7,8	7	10,3
MO improves the insight in other disciplines	8,1	7,3	10,0
MO approach is relevant for own discipline	7,9	7,3	7,6
MO proved helpful for communication	8	7,2	10,0
MO have a positive effect on the design process	7,7	6,6	14,3
MO have positive effect on the final design	7,3	6,2	15,1
Expects to use MO in daily practice	7,3	6,9	5,5

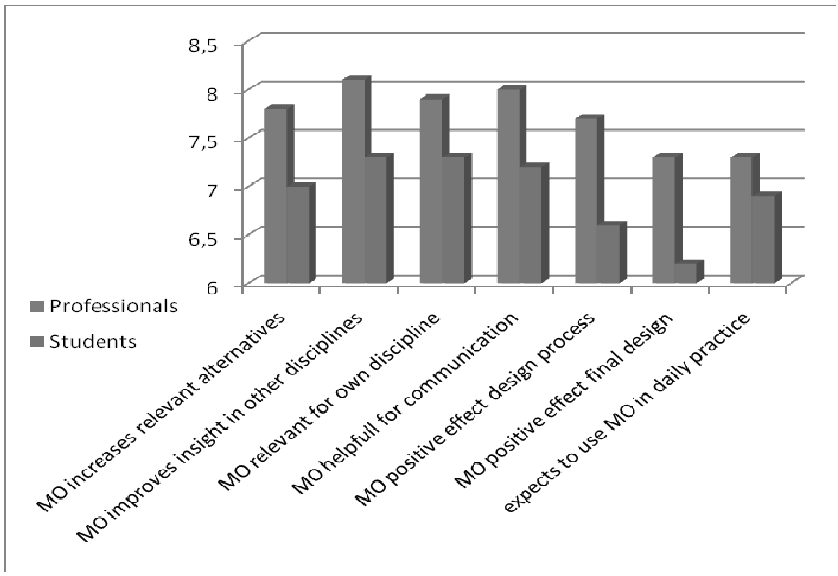

Figure 4. Comparison results questionnaires the later series workshop of two days for professionals and students, rating on a scale from 1–10.

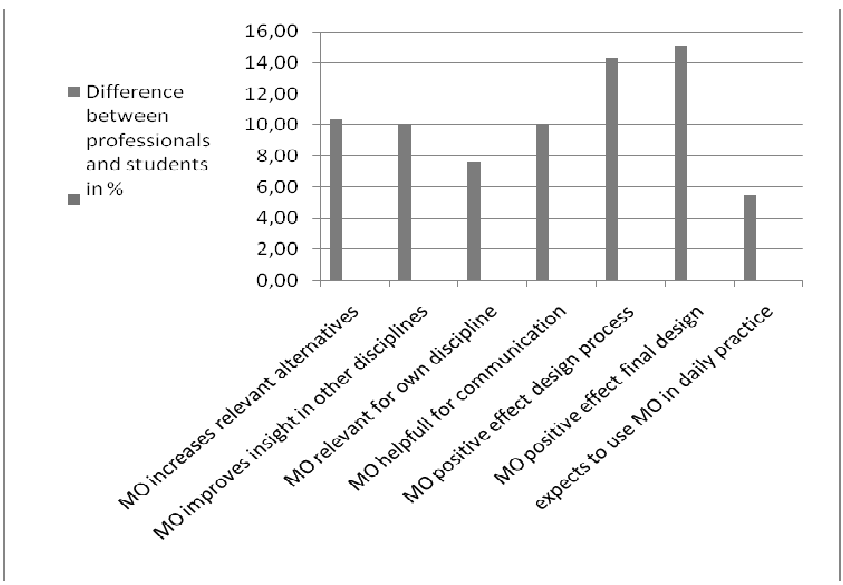

Figure 5. Relative difference score between professionals and students of the two final series workshops' questionnaires. Professionals responded on all questions more positive than the students.

The results of the questionnaires indicate that the participants thought the use of morphological overviews increases the insight in other disciplines, helps the communication and increases the number of relevant alternatives within the design process.

Surprisingly there is a rather small relative difference between the appreciations of professionals as compared to that of students see Figure 5.

5. DISCUSSION

Traditionally a design method is developed at a university where it is tested on students and then implemented in practice. In our case we choose to change this; the testing was done as near to practice as possible with professionals and then implemented at the university. The result was that, were normally the evaluation of the design method and its tools by practitioners lead to a lower appreciation than that by students; in this case the situation was reverse. The practitioners thought the design method and its tool of more value than the students.

As one of the effects of the design tools is the added value to insight and communication in multi-disciplinary design teams, we think that our approach is not only useful within the building (design) industry, but also in mechatronic/ergonomic design, industrial design and inclusive design. Contexts in which mechanical engineers work together with people from different disciplines with a more 'soft' or reflective approach to design. Also the experience of testing educational settings in practice instead of only in academic settings and how experiences from professional education and professional practice can flow back into academic education could be useful to the education of mechanical engineers.

6. CONCLUSIONS

In this paper we discussed the connection between building industry and university by multidisciplinary workshops for professional (architects and engineers). The professional workshops were organized for research into a new design education concept for architectural and engineering master students. This led to a set-up of student workshops as the starting point of a multi-disciplinary master design project.

From the questionnaires it was concluded that morphological charts were helpful in structuring communication of student design teams (score 7,2 on a scale 1–10) as well as that of the professional teams (score 8). Concerning design aspects of the use of morphological overviews, it was concluded that morphological charts were useful in structuring design activities of both practitioner (score 7,7) and student design teams (score 6,6). They were also helpful in improving the insight in each other disciplines (professional score 8,1 and students score 7,3), widening the field of relevant possibilities (professional score 7,8 and student score 7) and even is relevant for the own discipline (professional score 7,9 and student score 7,3) [11]. So clearly our integral design approach with the use of morphological overviews is appreciated both by professionals and students. Our presented approach of combining education for students and professionals is meaningful in the field of building design. Besides the good ratings of the questionnaires by the participants of both the student workshops and the professional workshops, the best proof of success may be the fact that the Integral Design workshops have become part of the permanent professional educational program of BNA (Royal Institute of Dutch Architects) since 2006.

An additional 'proof' for success is the fact that the largest Dutch building services consulting company asked us to provide training for their employees within the company, based on the concept of the workshops. This was after several employees of this company had participated in the professional workshops. This workshop was held in company on March 31, 2008. Sixteen professionals attended this workshop and their overall rating of appreciation was 7.5 on a 1–10 scale. So we presume that by using our integral design workshops with the use of morphological overviews, we prepare our students well for the multi-disciplinary design problems they have to face when designing zero energy buildings.

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